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INTERCONTINENTAL RAILWAY COMMISSION.

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PRELIMINARY REPORT

OF THE

EXECUTIVE COMMITTEE.

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# INTERCONTINENTAL RAILWAY COMMISSION,

1016 Vermont Avenue, Washington, D. C.

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*President:*

ALEXANDER J. CASSATT.

*Executive and Disbursing Officer:*

R. M. G. BROWN.

*Secretary:*

EDGAR Z. STEEVER.

*Clerk:*

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C. FEDERICO PÁRRAGA, of Colombia.

LEFFERT L. BUCK, of Ecuador and Peru.

LUIS J. BLANCO, of Venezuela.

JOHN STEWART, of Paraguay.

PRELIMINARY REPORT  
OF THE  
EXECUTIVE COMMITTEE OF THE INTERCONTINENTAL  
RAILWAY COMMISSION.

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2 Dec 13. 2. T.  
The executive committee of the Intercontinental Railway Commission submit the following report for the information of the several governments interested in establishing better means of intercommunication between the republics of the Western Hemisphere. This preliminary report is simply intended to exhibit, in a general way, the progress of the surveys under the direction of the committee, as the details of the enterprise and the conclusions to be arrived at must await the completion of the field surveys and the preparation of the final maps.

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The better to show this progress, the operations of the several parties will be shown separately. It will be remembered that when the full Commission adjourned in April, 1891, an executive committee of five members, consisting of Mr. A. J. Cassatt, the president of the Commission; Mr. C. F. Párraga, of Colombia; Mr. L. L. Buck, of Ecuador and Peru; Mr. Luis J. Blanco, of Venezuela, and Mr. John Stewart, of Paraguay, all of whom were expected to remain in the United States, was appointed with full and sufficient powers to conduct the business of the Commission during the suspension of the regular sessions of the full delegation. Mr. Hector de Castro, who had been appointed secretary in January, 1891, resigned to take effect June 30, 1892. Lieut. R. M. G. Brown, U. S. Navy, was appointed executive and disbursing officer March 10, 1891, and on the 20th of December, 1892, the executive committee elected Capt. E. Z. Steever, U. S. Army, who had been serving in the office as engineer since April 1, 1891, secretary of the Commission, the duties of said position to be performed in addition to his other duties.

The executive committee has maintained in Washington a central office, which has been under the immediate charge of Lieut. Brown, assisted by Capt. Steever, and Mr. H. S. Flynn, as clerk. With this small force all the business of the Commission has been transacted and the home expenses kept down to a minimum.

The executive committee, with the assistance of Mr. H. G. Davis, chairman of the committee on finance, and Mr. R. C. Kerens, chairman of the committee on trade and resources, have met from time to time, whenever necessary or advisable, to approve the steps already taken or to decide upon more important matters for the future. Its chairman has been in constant communication with the Washington office and has supervised the conduct of the survey through that channel.

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## CENTRAL AMERICA.

### CORPS No. 1.

Lieut. M. M. MACOMB, *Fourth Artillery, U. S. Army, Engineer in Charge.*

Lieut. S. M. FOOTE, *Fourth Artillery, U. S. Army.*

Lieut. L. W. V. KENNON, *Sixth Infantry, U. S. Army.*

Lieut. A. S. ROWAN, *Fifteenth Infantry, U. S. Army.*

Lieut. SAMUEL REBER, *Fourth Cavalry, U. S. Army.*

Lieut. C. A. HEDEKIN, *Third Cavalry, U. S. Army.*

Mr. C. W. HAINES, *Civil Engineer.*

Dr. W. C. SHANNON, *Assistant Surgeon, U. S. Army.*

The members of this expedition sailed from New York fully equipped on the 20th of April, 1891, bound for Guatemala City, where they arrived on the 9th of May, and were cordially received and shown every attention and courtesy by the Executive and other officials of the Government.

On the 21st day of May the President of Guatemala issued the following order:

The recommendations of the International American Conference are accepted by the Government of this Republic in so far as they refer to communications by railway, and the department of foreign relations will, in consequence, give the necessary orders to carry out these recommendations, making at the proper time a report to the national legislative assembly.

On the 22d of May Mr. Samuel Kimberly, United States consul-general at Guatemala City, received a communication from the National Government, informing him that—

The minister of public works has given orders to the superintendent of the hippodrome to place at the disposition of the International Commis-

sion of Engineers such part of the building as may be required to establish their offices and storerooms. If the members of the Commission have documents, which from their importance they may desire to preserve safely, the superintendent of the building has instructions to keep them in his office under his special care, and the official engineer, Mr. Paschke, has instructions to consult with the Commission in everything thought to be of use.

The foregoing, as well as the subsequent action by the Government of Guatemala, shows the interest taken in the welfare of the work inaugurated by the Intercontinental Railway Commission.

Four young officers of the Army were afterwards detailed to assist Lieut. Macomb in making the surveys in Guatemala. All arrangements being concluded, part of the expedition started, under the orders of Lieut. Reber, with animals and supplies, to establish camps at Escuintla, Retalhuleu, and Quezaltenango. While in the city of Guatemala the engineers prepared a map of the boundaries of the city and did other preliminary and topographical work.

The actual survey began at Santa Lucía, a branch line between Escuintla and that point having already been surveyed by the Guatemala Central Railroad Company. Under date of May 31, 1891, Lieut. Macomb submitted the following outline of his plans for field work:

- (1) To run a line from Santa Lucía to Retalhuleu.
- (2) To examine the country between Retalhuleu and the Mexican line toward Tapachula, Mexico, via Rodeo, Malacatán, and Tuxtla Chico, thus finishing the examination of the lower line.
- (3) To survey a route to San Marcos and down the Río Cuilco toward Amatenango. The Cuilco belonging to the Chiapas drainage, its valley would offer the best line by which to reach the highlands of Guatemala from the direction of San Cristóbal.
- (4) To run a line up the valley of the Cuilco toward Quezaltenango and Totonicapan.
- (5) Back to Guatemala from Totonicapan, examining two routes.

Accordingly, a careful instrumental line was surveyed from Escuintla, via Santa Lucía, Patulul, and Retalhuleu, to Ayutla, on the Mexican boundary, the stadia method being employed and numerous barometric observations taken at important points for the determination of altitudes. The country was covered with a network of triangles for the accurate location of

the important points in the neighborhood of the lines surveyed, and many astronomical observations for latitude also taken. Ayutla was reached January 26, 1892, the survey to that point from Escuintla having been under the immediate charge of Lieut. Foote, while Lieut. Kennon had immediate charge of the survey of the adjacent lines and of the examination of the Cuilco region between San Marcos, Quezaltenango, Huehuetenango, and Amatenango-on-the boundary. From the neighborhood of Quezaltenango another route was surveyed via Totonicapan and Chimaltenango back to Guatemala City, and subsequently the instrumental line was taken up at Escuintla and carried via Platanar to the Salvadorean frontier.

Owing to the conditions existing in the section under consideration, Lieut. Macomb deemed it inadvisable to confine himself to the survey of a single line, and therefore examined a broad belt of country in order to determine not only the practicability of a railroad, but to ascertain the best route of several that presented themselves for an intercontinental trunk line.

From the data gathered three lines are practicable across Guatemala from the Mexican boundary to Salvador.

The first is of light grades and comparatively easy construction, at a general level of between 250 and 600 feet above the sea. This would skirt the foothills and pass through forest and grazing lands.

The second is from 800 to 2,000 feet above sea level, running along the lower edge, or near the middle of the coffee belt, the richest and best cultivated district of Guatemala.

The third is through the "altos" (highlands) in the vicinity of the large cities, in a climate agreeable to our Northern people, and to those of the temperate zone generally.

Of these three lines two are pronounced good by the engineer in charge, preference, however, being given to the one skirting the mountains and passing through the coffee belt. On the lower line, via Ayutla, Escuintla, and Platanar, no serious engineering difficulties present themselves; the construction would be cheap, easy, and quick, the most important item being the crossing of the numerous streams by suitable bridges. Still, this is not regarded as the best location for an intercontinental trunk line, owing to the absence of population and products. The line along the base of the mountains and running north of Mazatenango, Santa Lucía, and Escuintla is therefore deemed the best, as it would drain a fine country



now being developed and afford a large local traffic by reason of the coffee, sugar, rubber, and fruit trade.

Tracings of the lower line have been received from the field and are on file in the central office in Washington.

Owing to an affection to his eyes, Lieut. Hedekin was relieved from duty with the corps in January, 1892, and was replaced by Lieut. Rowland G. Hill, Twentieth Infantry, U. S. Army, who reported for duty at Guatemala City, March 31, 1892. Other changes also occurred. Lieuts. Foote and Reber were relieved in April and Lieut. Rowan and Mr. Haines in August, 1892. Mr. H. J. Humphrey, an experienced draftsman was sent to join Lieut. Macomb and reported for duty in September, 1892.

After completing the survey of Guatemala that of El Salvador was commenced, the frontier being crossed in August of 1892. At latest accounts the corps were between San Salvador and San Vicente and hoped to carry the line through to Boca Culebra, at the mouth of the Savegré River, in Costa Rica, where connection would be made with the line started by Mr. Shunk in that locality.

In response to a request of Lieut. Macomb's, the United States minister to Salvador, Mr. R. Cutts Shannon, communicated with the authorities and received assurances of the warm interest taken by the Government of Salvador in the progress of the work being conducted by this Commission. Accordingly orders were issued to the heads of departments to give all possible aid, to the custom-house officials to admit the property of the surveyors without duty, while the free use of the telegraph for official business was also tendered. Mr. Tomasso Stech Bonellé, Government engineer, was assigned to duty with the corps as consulting engineer.

Lieut. Macomb, under date of August 11, 1892, reported from Santa Ana as follows concerning the condition of railway construction in Salvador:

The Government line from Acajutla has been extended to La Ceiba, a point about 5 or 6 miles west of Santa Tecla or Nuevo San Salvador. Between Santa Tecla and the terminus at La Ceiba is some heavy work requiring some viaducts and a couple of tunnels. From Santa Tecla to San Salvador the railroad grade is complete and it is now operated as a tramway, with mules. The Government engineer is at present busily engaged on this final piece of work which will place San Salvador in connection with the seaport by an all-rail route. Now it is rail to La Ceiba, stage or horseback to Santa Tecla, and tramcar thence to San Salvador, the whole trip taking about six hours.

It is considered certain that the line will be completed.

Mr. Albert J. Scherzer's line starts from the Government line, at a point west of La Ceiba, and swings around to the northwest, terminating at Santa Ana.

Mr. Scherzer has just returned from Europe with the necessary capital (and with much material ordered) to complete this line, and it is regarded as a sure thing.

The French company's line extends from the capital to La Union, the seaport on the Gulf of Fonseca. They have only made reconnoissances, however, and have done no work.

These are the lines with which we will have to connect, but thus far we have been unable to get any complete maps from any of them, and probably none exist. It is a difficult thing to make a satisfactory connection or show the Commission how our work connects with that proposed without maps. That is the great trouble we have encountered thus far in trying to make use of other work, the records and maps are incomplete and inaccurate. Hence we have had to do over, in some cases, work which has been done once before, but of which the records were lost through some carelessness.

I hope to be able to find a feasible line from the west boundary of Salvador connecting either with Santa Ana or Sonsonate.

This done, I think we may assume that the route as far as San Salvador is fixed. Our work then will consist in finding an acceptable route to Guascorán. There will be some heavy work required here, but from Guascorán to Chinandega I am informed that the country is flat and favorable for railway construction.

I will forward a report of our preliminary work between Escuintla and Santa Ana as soon as I can get the data in shape. Mr. Hill and I have been over some rather unhealthy country. During the last two weeks I have been incapacitated for field work for some days, and am now under treatment. Mr. Brooks (quartermaster, etc.) was very ill for two weeks, and several of the natives have been down. Mr. Hill is still well and has been free from attacks of fever. Messrs. Kennon and Shannon have been working in the higher country and report themselves well.

I have not asked for any more officers because I believe we can work more economically as we are.

Under date of September 22, 1892, Lieut. Macomb reported as follows:

I went over with Mr. Scherzer, the best railroad man in this country, and saw just where he proposed to locate his line from Santa Ana toward San Salvador.

He is doing his work so well that I shall connect with it by triangulation and not resurvey what he has done. We soon shall start into the east of San Salvador, toward San Miguel. Here the country is exceedingly difficult and, it is said, impracticable, but this is what we shall find out during October. Just now the roads are horrible—mere ditches of mud and water, and worse than in Guatemala last year, because there has been a good deal more rain here. I expect to reach Managua in latter part of November or first week in December.



Under date of November 16, 1892, Lieut. Macomb reported that—

I estimate that it will take us until the end of June next to complete our work and connect with Mr. Shunk's initial point. I understand that he is now working south from San José de Costa Rica, and I expect to connect with the Costa Rican Road at San Ramón.

We have collected a great deal of material of interest bearing on the regions through which we have passed and the topographical work has been very carefully done and is based upon a net of triangles. For the credit of all concerned and to give a permanent geographic value to our work, I consider it important that triangulation should be carried to the end of our line. In no other way can such good results be obtained. When our notes are finally reduced the geodetic positions of all the main points in the vicinity of our line will be determined, and on this basis will rest our final plans and profiles.

To make an intelligent selection of an acceptable line through this country requires a very careful preliminary study of the topography, which should be laid down in all the detail which the character of the work permits. Upon this map, with the personal knowledge of the country acquired in actual field work, a good location can be made.

In order to sufficiently expedite the work of Corps No. 1 so it might complete the survey of Central America within the time and within the funds at the disposal of the Commission, instructions were dispatched to Lieut. Macomb to discontinue his triangulation and to confine his work to that of a preliminary railroad survey. Accordingly he closed out his system of triangulation by the occupation of the volcano of San Vicente, which gave direct connection with La Libertad, one of the best determined points in that section. Lieut. Kennon was then detached and sent to Punta Arenas, Costa Rica, with the necessary equipment and with orders to organize a small party, seek Mr. Shunk's initial stake on the Río Savegré, near Boca Culebra, and work northward, running a good transit and stadia line until connection should be made with the main party coming southward. It is estimated that Lieut. Kennon will have about 200 miles to cover during the months of February, March, and April, while the main party would survey about 280 miles and be in the neighborhood of San Juan del Sur by the 1st of May, with its field work completed.

It is not intended to duplicate any work now completed, and accordingly the existing line of the Nicaragua Railway from Chinandega to Granada will be accepted as it stands. It is understood that our minister, Mr. Shannon, was about to secure, for the use of our surveyors, tracings and other data covering

not only the operated lines, but also those studied, although not yet constructed.

Lieut. Macomb had connected, at Sitio del Niño, with the Scherzer line, now being built between Ateos and Santa Ana, and had run a line north of the volcano of San Salvador. The capital being difficult of ingress and egress, Lieut. Macomb is of the opinion that it would be better to put San Salvador on a spur rather than attempt to build a trunk line through it. Under date of January 6, 1893, the chief of Corps No. 1 reported that his party were working along the slopes of the volcano of San Vicente, a fine peak, with much ground available for coffee, indigo, sugar, and cattle, and possessing a good water supply. The line run would pass within 2 or 3 miles of the town of the same name and thence probably via Usulután, near the coast, continuing to San Miguel through a good railroad country, and one sufficiently rich to afford good opportunities for future development. From San Miguel the line is expected to proceed via Santa Rosa and Pasaquina towards Nacaome, in Honduras, thence to Choluteca, and finally to Chinandega, thus connecting with the Nicaraguan railroad. On reaching this latter point the survey would be discontinued and resumed again at Granada, the farther terminus, and thence continued towards the head of the Río Tempisque in Costa Rica, and so on to Punta Arenas, or some other point, to a junction with Lieut. Kennon's section.

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## SOUTH AMERICA.

### CORPS No. 2.

WILLIAM F. SHUNK, *Engineer in Charge.*

ROBERT BURGESS, *Assistant.*

WILLIAM J. O'CONNELL, *Topographer.*

JAMES PARKER, *Assistant.*

D. M. MARTINEZ, *Assistant Topographer.*

FRED N. OGDEN, *U. S. Navy, Surgeon.*

THOMAS F. DEMPSEY, *Rodman.*

This party, under the direction of Mr. William F. Shunk, was assigned to survey the country from Quito, Ecuador, northward and through Colombia toward the Isthmus of Panama. Being fully equipped, it sailed from New York on the 10th of April, 1891, for Guayaquil, Ecuador, which point was safely reached on the 25th of the same month. At Guayaquil the governor

of the province and the United States consul-general did all in their power to assist the party. Many unavoidable delays were experienced, but the Government offered transportation and every possible facility to convey the surveying corps to Quito.

The distance from Guayaquil to the capital is about 270 miles, there being rail communication as far as Chimbo, but the rest of the distance, about 200 miles, has to be covered by means of horses or mules.

The governor of the province and his staff accompanied the party on the first day out from Guayaquil. The central government issued orders to the authorities to facilitate the progress of the engineers and no efforts were spared to carry out these instructions.

On the 3d of May Riobamba was reached and the governor of the province of Chimborazo called to welcome the party. To return in some degree the many courtesies received, the surgeons attached to the surveying corps lent, on various occasions and gratuitously, their professional services.

Quito was reached on the 6th of May. A committee of citizens, appointed by El Señor Antonio Flores, the President of the Republic, met the party and escorted it to the city. During the stay at Quito government officials and private individuals were constantly extending hospitalities and courtesies to the members of the surveying parties. After consultation with the minister of public works, who furnished Mr. Shunk with maps and other valuable information, the necessary arrangements for starting having been made, the first camp was established at a point 3 miles from Quito for the purpose of completing the organization of the working parties. The temporary ill effects produced by the great altitude of this region soon disappeared and the work began in earnest.

The initial stake of the survey was set in the southeastern suburb of Quito, June 3, and a daily average progress of  $2\frac{1}{2}$  miles made to Ibarra, which was reached July 12, 1891. The geological character of the country is aptly described by Mr. Shunk in the following words:

This whole plateau valley, together with its outer slopes on Amazon and Pacific waters, appears to have been built up coördinately with the gradual lift of the volcanic border peaks; and those volcanoes delivered, almost exclusively, mud and dust. The surface material therefore, for an unknown depth, is mainly clay of some kind, white, yellow, brown; and black seams of comminuted pumice occur, and beds of clayey conglomerate, holding

angular porphyry and trachyte blocks, all sizes, from a piece of chalk to a house, stiffened in the argillaceous matrix to a half-rock, the consistency of hard pan; here and there strata of water-rolled gravel and shingle; very rarely, and low down, a streak of lava. Little outcropping rock is visible, excepting the high up ridges and crater rims, and all such rock is porphyritic. The viscid mud discharge came to rest at a moderate inclination, and the volcanic dust showered down on it for the most part cross-wise of the valley before the prevailing easterly winds, thus raising or helping to raise the "nudos," or knots, which tie the cordillera parallels together and form the chief obstacles to a good railroad line. The original declivity of this earthen output was 12 or 15 degrees at top to where it abutted with the steep crater cone; thence it gradually flattened to about 5 degrees at the base.

Before weather-wear began, assuming that to be supposable, the topography must have been not unlike the surface of a row of hippodrome tents set end to end, 30 to 50 miles wide and 50 to 100, or upwards long; where two touched, a nudo; the tuck-up poles baptized Chimborazo, Tunguragua, Cotacachi, and so on. Erosion, however, has done marvellous sculpture on this symmetrical mold. It seems to have begun at the summits, where rain and snow began most vigorously. The tendency was to form an annular depression about each central cone, a ring pond overflowing at low spots. Hence broad based, smooth and cultivable triangles of the ancient surface surround every typical peak or crater, their points upward, like the cloven calyx of a rose against the bud, with abrupt counter-slopes, and divided by chasmal ravines narrowing downward to cañons. Good drainage has preserved these significant surfaces and plenty of it has scoured the cañons deep, not only on the mountain flanks, but across the plains and down the outlet valleys to ocean or river. Along the lofty ridges between those old craters, dead and alive, the same tendencies and effects are manifest, diversified, however, by occasional concentration of wash in the coves and immense landslides, either rewrought where they fell or dissolved and distributed over old lake bottoms to reappear for us as plain country, the garden ground of the Republic.

These mountains are grassed, but treeless; above the shrub limit, pale green with dashes of tawny; then shrubs of the myrtle kind, on the lower declivities, chiefly in the coves and ravines; then the fat pastures of the plain, grain fields, gardens, clumps of fruit trees, and everywhere the eucalyptus as a feature in the landscape almost as characteristic as the adobe fences, topped with cactus and magney.

It is remarkable that all surface material here seems to make "adobe" and stands, very much like our "bluff" along the Mississippi, near Vicksburg and Natchez, at the vertical or at slight deviations therefrom, scaling hard where exposed and greening over with a finely textured protective moss.

The breaks or "quebradas," as they are locally called, which net the country wherever water runs in the wet season, invariably have a tin-funnel cross-section, slant above, wall-sided below, whether 10 feet deep or 500, dropping as a rule abruptly from the surface to an angle of forty-five degrees and rounding down to the perpendicular; so that, in our experi-



ence, a trifling ditch to appearance usually proves impassable by horse or foot as a profound chasm. The stream, too, is always sinuous, the tusks and indents locking like the teeth of a porpoise or the sutures of a skull. Another feature is that they rarely shoal up stream, so that in most cases economy can not be gained by swerving the line.

The first hundred kilometers average each an estimated cost, for grading, masonry, and bridges, of \$20,000, equivalent to about \$32,000 per mile, and require no gradient exceeding  $3\frac{1}{2}$  per cent.

From Ibarra the line was carried forward by way of Toquando and Chota valleys, over difficult ground, consuming considerable time, the stay in the pit of Chota—only 5,200 feet above tide, amongst barren clay hills—being anything but agreeable. On the 23d of July the corps was divided into two sections, section 2, under Mr. Burgess, continuing the line of survey up Chota and Huaca valleys, while Mr. Shunk, with section 1, advanced to the neighborhood of Tulcán and started another line northward from the southern side of Nudo de Huaca, about 9 miles south of Tulcán.

At Tulcán, as at all other provincial capitals in Ecuador, the governor courteously offered his services to the representatives of the Commission. Before crossing the frontier of Colombia, the prefect of Obando, the southernmost province, sent his card and placed himself at their orders. Soon after arrival at the first camp north of the boundary the surveyors were visited by a committee of citizens of Ipiales, offering welcome and bearing a letter from Señor Burbaro, the prefect of the province. Next day Mr. Shunk and his comrades called, by appointment, upon the prefect, and were most cordially welcomed and entertained at luncheon.

From Nudo de Huaca Mr. Shunk's line was carried across the Río Telles, near its junction with the Guaitara, by way of the latter stream, the Guapuscal and the Chimbatangua, to the village of Tanqua; thence turned southward and doubled into the valley of the Taruqui, where another return was made southward, followed by a final one north to the great "pastures," near the village of Tacuanquer, thence to the summit up the southeastern flank of La Galera, a distance of about 25 miles on a gradient which should not exceed  $3\frac{1}{2}$  per cent on location, with two or three intermediate slacks. Ten miles of like gradient carries one down to Pasto, about 80 miles from the start near Tulcán, and 216 miles from Quito. The success-



ful conduct of the line to Pasto, overcoming the most difficult, probably, of the summits, was therefore happily effected. This involved the ascent of the flank of "the huge ruined cone of La Galera, 15,000 feet above tide, forming a pit 4 or 5 miles athwart, being itself on the rim of a still more stupendous ruin, threefold that diameter, its edge slightly dipped toward the south, cloven by Pasto River toward the north, and inclosing a circular tract of hill country benching down 2,500 feet vertical to the exit of drainage northward, where the city stands. Viewed from the south, therefore, on Guaítara waters, the summit, heretofore unsuspected, appears to be a wall of mountain, slightly saddled or wind gapped." It remained for Mr. Shunk's party to be its discoverer, and, using the privilege of such, named it La Cima de Santa Gertrudis.

The alternative to the upper Guaítara route, run by Mr. Burgess, via Tuquerres, compares with the line run by Mr. Shunk, in length about 50 to 30.

Having carried the line prosperously into Pasto, the problem was to get successfully out, for the "next stage of the survey required the crossing of the profound valleys of the Juanambú and the Mayo, divided by a lofty cordillera, to the valley of the Patía. North of Pasto, the basin in which the city lies is bounded by a high ridge, formerly connected with La Galera, now traversed by Pasto River in cañon. The whole country north of that bounding ridge tumbles down 6,000 or 8,000 feet within 15 miles to the Juanambú, flowing westward, and in the main is heavily timbered and beset with spurs ranging north like the teeth of a comb." However, owing to the intelligent studies of Mr. Shunk, he found a small brook, the Chichatoy, flowing westward, about two and one-half miles in length, into the Pasto River, north of the high ridge bounding the basin wherein the city lies, and giving access to the comb-like spurs near their roots, and thus enabling the engineers to avoid doubling ridges and ravines along three parallel affluents of the Juanambú, and owing to a long bend southward on the upper course of that river, above their mouths, to approach it near Tablon, thereby largely reducing the necessary descent to a crossing.

The neighborhood of Tablon is a ruling objective, whether the old Arenal Summit, the thoroughfare for generations between the Juanambú and the Mayo, be crossed or one of the streams from the great divide further east be followed. The ascent to the Arenal exhibited a wilderness of sharp set ridges and hollows. The Vado, eastward, was perceived to be a cañon

water, equally uninviting, besides heading up in the wrong direction, without counter sloped watershed. The Quiña, largest of all the tributaries in that quarter, appeared unquestionably to be the preferable route and was so found; the summit as low as Arenal, sharp edged and indicating a tunnel about 2,500 feet long. The neighborhood of Tablon was surveyed extensively to provide a reserve of development, if needed. The upper valley, however, proved to be a plain, level athwart, about 300 meters wide and having a quite regular inclination of 5 degrees. Taking advantage of this topography and of a suitably located lateral ravine, it proved better to develop there rather than at the foot of the valley, thus gaining 2 miles of distance by means of a flaked line on comparatively inexpensive ground and attaining the proper elevation for the tunnel.

The Quiña Valley was shaley and slaty, the hills rounding down very uniformly in profile, though cut by drainage, with an increasing pitch toward the stream. North of the tunnel, on the Mayo slope, the surveyors traversed a region of crumbly clays and soft pumice rock very much weather worn. True contours would lie in bights between thin-nosed spurs like a slack clothesline between its props. The concaves are fittable, as a rule, by our curvature; cuts through the points deep and short. The Mayo at the crossing, about 6 miles north of La Cruz, is a 60-foot stream in cañon valley, 800 feet wide and 300 feet deep, requiring a viaduct of that size. At the end of 10 miles (16 kilometers) down the valley it began to break into impassable cañon and fingery, wall sided spurs, which were avoided by turning through a short tunnel into the valley of Las Palmas.

Seven miles additional brought Mr. Shunk to a junction with the alternative line surveyed by Mr. Burgess, said junction being about 76 miles (121.6 kilometers) from Pasto, by measurement of an approximate location on the field maps. Free use of curvature, a course clearly prescribed by both physical and commercial considerations and the line skillfully located, the cost of these 76 miles north of Pasto will, in the opinion of Mr. Shunk, not exceed the average previously given for the reach north of Quito, while the maximum gradient required will be less than  $3\frac{1}{2}$  per cent.

Material for masonry exists in the stream beds. Timber for ties is convenient and sufficient, except in the Las Palmas Valley, where the supply is scanty, limited to small groves in the lateral ravines.

From Las Palmas the line was carried via Cuevas to Popayán, situated at the head of the Cauca Valley, camp being pitched near that city December 4, 1891. South of Popayán the line crosses the ridge of Roble, which is the divide between the headwaters of the Patía River flowing into the Pacific Ocean and those of the Cauca emptying into the Caribbean Sea. Ridge of Roble also connects the oriental and occidental cordilleras. From Popayán the survey was conducted via

Cajibió to Cali, which was reached January 18, 1892, the division of the corps into two sections materially increasing the rate of progress of the work.

The distance from Quito to Cali by the Guaítara route is about 490 miles (788 kilometers) and by the Tuquerres route 530 miles (853 kilometers) making an average of about 70 miles per month, commendable progress, when one considers that the route lay through some of the boldest mountain regions of South America.

Concerning the section between Quito and Popayán, Mr. Shunk is of the opinion that \$32,000 per mile (\$20,000 per kilometer) would be a fair valuation for grading, masonry, and bridges, provided the line were well laid in gross and carefully located in detail; that such a line exists, awaiting the finder; and that it must be found eventually if the road is to be built, as there does not appear to be business in sight or in the near prospect to warrant a larger average outlay, if even an outlay so large. That sum in the United States would prepare the roadbed through pretty difficult country; the grades and curves admissible in Ecuador and Colombia go far to offset the peculiar obstacles encountered. Good drainage would be a prominent item of expense. On the other hand, cuts can be taken out to steep slopes in that frostless region, judging not only by the character of the material in place, but by work already done on the highways, whether by storms or by hand. As a rule, the steeper the pitch the better it stands. There would be three tunnels required on the section now under consideration. One about a mile in length under Boliche Summit, another 2,500 feet long under Quiña Summit, and a short one under the Ridge of Roble.

In regard to the reach between Popayán and Cali, Mr. Shunk reports that there appeared to him to be three alternative lines awaiting examination:

First. A detour by way of the Cauca River from Popayán to Paso la Bolsa, north of Buenos Ayres. Second. From Popayán across country by way of Duende or vicinity to the valley of the Piendamó, thence to and along Cauca River to Paso la Bolsa. Third. From Popayán along the foothills of the central cordillera adjacent to the national road north, by way of Jimena, to the ridge between the rivers Piendamó and Tunía, thence along that ridge to the vicinity of Aganche, whence a descent may be made along the southern flank of the valley of the Ovejas to the Cauca near Jelima and thence to Paso la Bolsa. At the latter point the valley opens. There is plain ground and no difficulty to Cali.

Before location, the Ridge of Roble, with the neighboring country between Los Arboles and Popayán, deserves particular study, for there are several alternatives inviting attention. Of course but one could be followed.

From Quito to the vicinity of Los Arboles, Mr. Shunk is of the opinion that the line actually run is pretty near the right ground, assuming it to be inadmissible to put Quito itself on a spur.

Corps No. 2 started the line north from Cali January 25, 1892, and in three weeks achieved the distance thence to Cartago; making, in round numbers, 24 miles (39 kilometers) the first week, 60 miles (96.6 kilometers) the second, and 40 miles (64.4 kilometers) the third week.

They were delayed more or less by foul weather, and, on the reach between Cali and Palmira, by exceedingly difficult ground to get over rapidly. The Cauca there traverses a sodden flat through dense wilderness containing a network of high-water sloughs, lagoons, and bayous. The road was very devious, but was necessarily followed. The bridges on it had been swept off by freshet two and a half years before, a circumstance that so obstructed transportation that the progress of camp regulated the progress of the survey.

Owing to the frequent fords or portages in mud or water, averaging probably 500 to 700 feet asunder for a long distance, camp moved slowly.

These 124 miles (200 kilometers) are without serious obstacle to cheap construction. The Cauca River near Calí, requiring a bridge 450 feet (137 meters) long, and the flood waterways to be provided in the vicinity of the river, make the division from Calí to Palmira more expensive than that from Palmira to Cartago.

Throughout the latter the alluvion of the valley, a plain sloping toward the main stream at a declivity almost imperceptible, borders the foothills along a winding line of demarcation with curves and indents like a sea margin. The railroad would cross those bays and coves on fast ground, with hillside excavation around the capes and through cuts through the occasional isthmuses, pretty largely in a gravel formation good for ballast. It is a well-watered country, rivers and brooks from the central cordillera abounding, and will necessitate ample provision for drainage. Timber convenient for ties and material for masonry obtainable from the water channels.

An approximate estimate places the 440 miles (708 kilometers) from Quito to La Bolsa crossing of Cauca River, south  
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of Cali, at the previously given net rate of \$32,000 per mile (\$20,000 per kilometer) for grading, masonry, and bridges; thence to the 487th mile (784th kilometer) at Cali, \$16,000 per mile (\$10,000 per kilometer), and thence to the 611th mile (983d kilometer) at Cartago, \$13,000 per mile (\$8,000 per kilometer).

The survey was carried to the camp of the corps,  $1\frac{1}{2}$  miles north of Cartago, at noon of February 15, 1892.

At this point the party was divided, Mr. O'Connell continuing the line northward, while Mr. Shunk set out on an exploration of the Quindío Pass in search of a feasible route into the Magdalena Valley. On his return he overtook the main body February 27 at camp north of Manizales, finding in charge Mr. J. D. Garrison, sent out by the Commission to relieve Mr. Burgess, resigned.

The main road between Cartago and Medellin was followed by the line as far as Salamina, where a crossroad permitted access to the western side of Cauca River at Marmato, from which point progress northward was made by way of New Caramento, Valparaiso, the Farralones, Santa Barbara, and Caldas, to Medellin, the suburbs of which were reached Saturday, March 19, 1892, and the line extended through it on the 21st.

It should be observed that the survey northward from Cartago, being restricted to the public road, traversed a rugged region crosswise of torrent drainage from the Paramos and Nevadas of the central cordillera, and for the most part out of sight of the true field along the Cauca Valley, over ground quite impracticable for a railroad at a reasonable cost, except the reach between Cartago and San Francisco. A location could be found there descending the Chinchina River from the latter point to Cauca Valley.

Mr. Shunk, however, judges such a line inexpedient. Without apparent advantage of any kind it must be the longer and more expensive alternative, and would enter the valley near head of what is considered its worst portion, avoiding, therefore, no difficulties of importance.

Mr. Shunk had contemplated trying a line by way of the Risaralda and San Juan valleys, but a report on that country by Mr. Franklin White, presented at Palmira, caused its dismissal. Mr. White's reconnoissance, made in 1878, indicates a gradient of 7.7 per cent for about 9 miles (14.4 kilometers) at the summit, an ascent thither from the mouth of the Risaralda approximating 4,300 feet (1,310 meters) vertical, and a descent thence northward to the mouth of the San Juan of 6,700 feet



vertical (2,042 meters). The valley line, on a continuous descent, would obviously consume the difference only between those figures, or about 2,400 feet (731 meters), distributed over a length of more than 100 miles (160 kilometers). The interior lines, as tabled by Mr. White, seem to be the shorter of the two by about 8 or 10 miles (13 or 16 kilometers), a difference which it is thought would be more than extinguished by the development necessary to reduce gradient within the limit prescribed. On a whole, the valley line is deemed preferable to any other. The scheme of the work forbade an attempt to examine its roadless, wilderness declivities, and smoky Indian-summer weather prevented good views of it from the overlooking upland; but such glimpses as were obtained, the observations made at the crossings, and the information of residents satisfied Mr. Shunk that although there may be occasional bluff spurs or precipitous cañons, a road can be built there at moderate expense. Much, if not most, of the "cañon," so called, is firm hillside for casting work, and there are numerous reaches of "bench" or "bottom." Yet in the uncertainty of the knowledge acquired, the division from Cartago by way of the river to the mouth of the Poblano, in round numbers 100 miles (160 kilometers), is estimated at \$32,000 per mile.

After his arrival at Medellin Mr. Shunk reported upon his explorations and studies of the passes leading from the Cauca into the Magdalena Valley. From these it appears that while descending the Cauca the possibility of finding a line thence up the Paila Valley, or that of the next affluent northward, which would favorably approach a low summit of the central cordillera at the head of the Río Coello, a tributary of the Magdalena, was suggested. From Mr. White, many years resident in the State of Cauca, the best information concerning the country in the neighborhood was obtained. He confirmed the conjecture that either from Cartago or the Paila vicinity a lower pass than that of the Quindío would be found to the southward. He added that the ground in the valley of the Coello and its affluents offered easier construction than the valley of the upper Toche, northwest of Ibaqué, the latter being greatly cumbered with bowlders and other débris from the volcano Tolima. The distance by each of the general routes from Cartago to Ambalema, whether by the Quindío Pass or by the headwaters of the Coello, would be about 125 to 130 miles (200 to 210 kilometers). Judging the ascent from Cartago to the Quindío

Pass. at the time of his reconnoissance, to be decisive of the feasibility of the work, Mr. Shunk did not extend his journey beyond that pass. The summit tunnel under Quindió would approximate 2,500 to 3,000 feet in length, and would put the railroad 800 to 1,000 feet underground. The material to be penetrated is compact blue slate and shale. By reason of the flattening off of the eastern ravine a much lower tunnel would be greatly longer and therefore inexpedient. On the approach to Quindió Pass from the westward there would be light valley work from Cartago to the vicinity of Salento; thence to the tunnel heavy and curvy. Massing those subdivisions, Mr. Shunk thinks that \$32,000 per mile (20,000 per kilometers) would cover the cost of grading, masonry, and bridges; and that, as an approximate valuation, that rate might be used for the entire distance between Cartago and Ambalema, about 130 miles (210 kilometers).

The general map of Colombia seems to offer an alternative line southeastward instead of northeastward from Ibaqué to the Magdalena River, which line should ascend to the national capital by way of the Rio Bogotá.

Owing to impassable roads Mr. Shunk, while at Popayán, was unable to explore Guanacas Pass, but from information obtained it is believed a railroad is feasible from Popayán, in the Cauca Valley, to La Plata, in the Magdalena Valley, via this pass. The ridge of Guanacas is believed to be between 1,000 and 1,300 feet above the waters of Palacé River, and this would imply a tunnel of about 1 to  $1\frac{1}{4}$  miles long, provided an exit eastward at an elevation of 11,000 feet might be made. The elevation of Lago de Guanacas is given by the French expedition as 11,590 feet (3,533 meters), and it is assumed that the lake stands 500 or 600 feet above the stream into which it flows, and from which it appears to be distant  $1\frac{1}{2}$  miles. This assumed tunnel elevation could be surmounted well within the rate of limiting gradient, so that there is room for movement up or down in this conjecture without seriously dislocating the conclusions. The distance from Popayán to the tunnel is placed at 40 miles (64 kilometers), and thence to La Plata at 60 miles (96 kilometers). The cost of grading, masonry, and bridges from Popayán to La Plata, inclusive of a tunnel  $1\frac{1}{4}$  miles long (2 kilometers) at the ridge of the Guanacas, would not exceed \$40,000 per mile (\$25,000 per kilometer). Below La Plata there would be no difficulty to the sea as to gradient.

Doubtless there are other passes into the valley of the Magdalena, both north and south of Popayán, but time did not permit a search for them.

The surveyors were welcomed and offered service by alcaldes of towns and prefects of provinces, under orders from Bogotá, and the director of national mails and telegraphs gave the freedom of the wires in Colombia. At Pasto a formal reception and lunch, as at Ipiales, was tendered, courtesies were shown at Cartago, but especially at Medellin was the reception most hearty and cordial. The governor of the State had the engineers to breakfast at the Executive Mansion, an entertainment beginning at 1 p. m. and not ending till 6, with a distinguished company to assist. Then the business men tendered a supper, an elegant collation, a very solid assembly and an interchange of goodly expressions from 6 p. m. till midnight. This was followed by courtesies from the president of the School of Mines and the municipal council, together with numerous acts of kindness on the part of other individuals, including the American and foreign consuls.

At Medellin the corps was again divided into two sections, each taking the field at the beginning of April. Section I, under Mr. Shunk, went by way of Antioquia to Cañas Gordas, on the river Sucio; thence, returning to Antioquia, extended the survey southward up the left bank of the Cauca River to the ferry on the trail between Concordia and Titiribí, arriving at this rendezvous May 10. Mr. Garrison, with the second section, joined a few days later, having surveyed a line from Caldas by way of Fredonia to the mouth of the river Poblanco; thence through Jerico to the San Juan River, at the mouth of the Quebradona, and thence through Bolivar to the "Quiebra" summit of the western cordillera. He then connected his line through Bolivar by way of the Cauca Valley to the ferry above mentioned and returned to Medellin. Both had a good deal of foul weather, and Section II suffered from ill health.

From the mouth of the Poblanco, on Cauca River, 711 miles (1,145 kilometers) from Quito, or from Cauca River at the mouth of the San Juan, 20 miles (32 kilometers) down stream from the former point, a branch to Medellin would be feasible, the length of it the same by both lines, namely, about 46 miles (74 kilometers). The first line would ascend the Poblanco Valley, pass the summit in San Miguel Ridge near Fredonia, detour the heads of the Sinifaná, pass a depression in the spur projecting westward from the central cordillera near Awagá, ascend to a saddle in said cordillera at the source of the Quebrada Lejia, a few miles south of Caldas and

run thence by way of that town down Medellin River to the city of the same name.

The second line, descending Cauca Valley on its eastern slope from the mouth of the San Juan, would ascend the southern slope to the Sinifaná Valley to a junction with the Fredonia alternative near the river sources. The latter line appears to be preferable as occupying better ground, accommodating the country side better, and as being free from objectionable counter gradient. Both lines would serve the unique coal deposit of the Sinifaná Valley.

One or the other of these two lines seems to be the only practicable approach to Medellin from the Cauca Valley in this region. Mr. Shunk's studies along the road between Medellin and Antioquia revealed a topography insuperable by a railroad at a reasonable cost.

From the mouth of the San Juan the line through or near Bolivar encounters no special difficulty until that town is passed. Development then becomes necessary to overcome the abrupt rise of the cordillera to La Quiebra summit, about 2,000 feet vertical (610 meters) in a horizontal distance of  $1\frac{1}{2}$  miles ( $2\frac{1}{2}$  kilometers). Support for such development is offered by the Quebrada Linda, southward. West of the summit the country slopes off with a moderate declivity and there would be no great difficulty, according to information, in the way of a railroad thence to Quibdó on the Atrato, about 60 miles (97 kilometers).

From the mouth of the Río San Juan the main line descends Cauca Valley on its western slope, over ground alternately bluff, bench and bottom, cloven by frequent streams or dry beds of torrent streams, 50 miles (80 kilometers) to the city of Antioquia, 781 miles (1,257 kilometers) from Quito. Thence it develops up the valleys of the Río Tonusco and its northern affluent, the Toyo, to a tunnel 2,500 feet (762 meters) long at the head of the latter stream; thence following the western bank of a tributary of the Cañas Gordas River, and developing up the latter stream, reaches the village of Cañas Gordas, 35 miles (56 kilometers) from Antioquia, 816 miles (1,314 kilometers) from Quito. Barometrical observations by Mr. J. H. White indicate that northward from Cañas Gordas the river falls at the rate of about 2 per cent, and that thence forward, down the valley of the Sucio, no gradient exceeding  $1\frac{1}{2}$  per cent would be necessary anywhere.

Mr. Shunk values the main line from the Poblano to Antioquia at \$24,000 per mile (\$15,000 per kilometer) for grading, masonry, and bridges; the extension from Antioquia to Cañas Gordas, difficult ground, at \$48,000 per mile (\$30,000 per kilometer); the branch to Medellin and the branch to La Quiebra at \$32,000 per mile (\$20,000 per kilometer). The material to be moved is chiefly red or yellow clay, loamy or sandy to some extent, but for the most part stiff. There are exposures of slate and shale, frequently metamorphic. Here and there occur beds of pumice sand, indurated. Scattered blocks of



basalt, trachyte, porphyry and granitoid rock may be said to be characteristic of the whole interandine upland explored by this party. The boulders in the river bed are very much the same everywhere. South of the Patía Valley comparatively little clay will be met. From the point of entrance of the corps into that valley northward it is a predominant material in "excavation." Solid rock occurs so rarely and, in the absence of frost there, the material actually existing stands at so steep a pitch, that Mr. Shunk thinks the whole line might be estimated as loose rock at slopes of  $\frac{1}{4}$  to 1 @  $\frac{1}{2}$  to 1. Nowhere was building stone seen in the bed. It is found only in the stream beds. There it abounds. Streams also abound; so that by means of steam crushers ballast might be provided quite conveniently. All through the region herein reported on there is timber for ties.

On June 7, 1892, the corps set out northward from Medellín, down the valley of Río Porce, and followed that valley through the towns of Copacabana, Jirardat, and Barbosa to the bridge, a short distance below the mouth of the Río Grande.

The survey there was diverted from the immediate valley of the Porce and, proceeding along the highway through Pabon, formerly called Hojas Anchas, across the Río Guadalupe to Carolina, thence swung northward, again traversing the bridge north of Río Guadalupe to the Higueron Summit, a marked depression near the junction of the Guadalupe and the Porce, 854 meters (2,800 feet) above the said junction on one hand and only 185 meters (605 feet) above the San Pablo on the other. Thence the line was continued, still following the road along the crest of the divide between the Porce and Nechi to the town of Anorí, where the corps arrived July 1, about 83 miles (133 kilometers) from Medellín.

At Anorí the corps was divided, Mr. Garrison, with section 2, traversing the highway thence through Campamento, Yarmal, Turbaco, and Raudal to Cáceres, and Mr. Shunk, with section 1, going to the same destination by way of the hamlets of El Indio, Cruces de Anorí, Zea, and Cruces de Cáceres and the valleys of the Beguquillo and Cauca. The corps reassembled at Cáceres July 21, section 2 some days in advance of section 1, the former having made 73 miles of survey, the latter 84.

From Cáceres Mr. Shunk had expected to be able to cross northwestwardly to the divide between the San Jorge and the Sinú to a point about 20 miles (30 kilometers) southward from the Ciénaga Betancí. It was learned, however, that the trail in that direction did not go through, that it was in bad condition, and was, furthermore, a mere footpath, never yet passed



nor made to be passed by pack animals. However, as the flatness of the country would admit a line in almost any direction, the failure to proceed as anticipated became less important. Therefore the Cauca River was descended in canoes about 30 miles (48 kilometers) to Cucharal, the port of Ayapel. Cucharal is a hamlet of one house. The animals, sent ahead light by land, were one week in making the journey. At Cucharal the corps again divided, section 1, with the surplus baggage (everything that could be spared from the field), going down Cauca River in a canoe, and section 2 prosecuting the survey by way of Ayapel, Sahagun, Corozal, San Juan, and Turbaco to the Plaza of the Patriots, in Cartagena, 208 miles (334 kilometers) from Cucharal. Section 1 arrived in Cartagena August 7, section 2 August 26, 1892.

From Medellin to the neighborhood of the Guadalupe-Porce junction work will be comparatively light, the lower portion of the valley, north of Barbosa, somewhat more difficult than the upper. On the whole, Juniata Valley work. The section of the line ascending from Porce Valley, crossing the Guadalupe and tunneling Higueron Summit, is exceedingly rough ground. The Guadalupe viaduct would be about 250 feet (76 meters) high and 1,200 feet (366 meters) long. Higueron Tunnel is proposed to be 2,000 feet (604 meters) long, at an elevation of 4,625 feet (1,410 meters) above sea, 475 feet (145 meters) below the summit, 2,325 feet (709 meters) above the Guadalupe-Porce junction, and 130 feet (40 meters) above San Pablo at its western portal. The elevation of Higueron Summit is 5,100 feet (1,555 meters) above the sea. A gradient of 2 per cent has been assumed on the approach from the Porce, in order to cross the Guadalupe above the "Salto" (falls) and to provide for future betterments of line without exceeding the maximum gradient used elsewhere. From Higueron Tunnel the location would follow San Pablo Valley to the Nechi and descend along the latter stream to the vicinity of the Medio Luna, thence developing up the Quebrada Dorada to the divide (3,050 feet, 930 meters), sloping northward to the waters of Río Neri, whence a descent is made to the proposed crossing of Cauca River, about 5 miles (8 kilometers) south of Cáceres. The work on this section is not excessive. Mr. Garrison reports it to be on the whole an easy country, presenting no special difficulties, "merely a question of fitting the line to the ground and adjusting it to the topography of the streams."

From Medellin to the Cauca, near Cáceres, the rock formation is gold bearing, Antioquia being preëminently at present the gold-bearing State of the Colombian Union. Excavation would be mainly variegated clays, shales, slates, and schists, more or less metamorphic.

It is to be observed that neither of the lines on the reach between the Río Grande and the Cauca, near Cáceres, lies near the prospective location, though occasional views of that prospective ground, from overlooking heights, were obtained

by the surveyors. The line traced by Mr. Shunk north of Anorí was designed as a reserve against a contingency of defeat on the western line. Maps being very imperfect, and his information leading him to fear a prohibitory summit in the cordillera along Cauca River, he thought it prudent to examine the Quebrada Cruces de Cáceres, with a view, if necessary, to exit that way from the valley of the Nechi. Mr. Garrison's happy discovery of the summit at the head of Quebrada Dorada superseded Mr. Shunk's individual work and is unquestionably, so far as can be judged at present, the proper ground for a railroad from Medellín to Cáceres. A partial alternative might deviate from the junction of the San Pablo and Yarumal, which form the Nechi, to Anorí, and thence, descending toward the village of Tamí, connect with the proposed location part way up Quebrada Dorada. Mr. Shunk is of the opinion that an alternative is feasible from the same point of departure as the foregoing, by way of the Quebradas, Yarumal, and Oro, and thence down the eastern flank of Cauca Valley, through Raudal, to Cauca crossing.

Objections to this line are the height of summit west of Yarumal, 7,500 feet (2,280 meters) above the sea, and a greater length of 20 miles (32 kilometers) as compared with the proposed location. The crossing of the Cauca River south of Cáceres would approximate 700 feet (213 meters) in length; the banks firm, east side bluff, west side flat for a short distance; depth of water at ordinary stage, 8 to 10 feet (3 meters), with a flood range making it 12 feet (4 meters) deeper at high water. Bottom, shingle. Piers to be founded like those in the Allegheny, at Pittsburg. No crossing of the Cauca equal to this or at all comparable with it anywhere downstream was seen. Below Cáceres the river soon enters flat ground and laces the adjacent country with bayous.

Mr. Shunk's line from Anorí, by way of Cruces de Cáceres, calls for no particular remark, being about 25 miles (40 kilometers) longer than the proposed location. The summit near Tamaná mines, 2,300 feet (701 meters), is considerably lower than that at the head of La Dorada, 3,050 feet (930 meters); but in every other respect the line is at a disadvantage. From the Cauca crossing no material obstacle exists to a line northwestward to the upland between the Rivers San Jorge and Sinú, whence, trending northeastward, it merges in a surveyed line north of Ayapel and follows that survey, with occasional slight deviations, to Cartagena. After passing Ayapel, the country is rolling prairie and timber, better populated and better utilized than any region of like extent seen by Mr.

Shunk in South America. It is a very rich farming and cattle district. The only high ground met was the "Paloma" ridge, rising about 1,000 feet (300 meters) above tide between San Juan and Cayetano; but it would be taken on the slant, with good approach spurs both sides, and yet at moderate cost. The general elevation of the plane north of Ayapel is 120 to 150 meters (400 to 500 feet) above tide. It ascends northwardly and culminates in the Paloma. The approximate cost of grading, masonry, and bridges from Medellin to Cartagena is estimated as follows:

24.85 miles from Medellin to Barbosa, 40 kilometers, at \$12,000 .....	\$480,000
38.52 miles from Barbosa to foot of Higueron-tunnel gradient, 62 kilometers, at \$15,000 .....	930,000
13.67 miles from foot of tunnel gradient to western portal, 22 kilometers, at \$45,000 .....	990,000
55.92 miles from Higueron tunnel to and across Cauca River south of Cáceres, 90 kilometers, at \$15,000.....	1,350,000
239.86 miles from Cauca crossing to Cartagena, 386 kilometers, at \$12,000 .....	4,632,000
Approximate cost.....	8,382,000

Average, \$22,500 per mile; \$14,000 per kilometer.

The railroads now building would reduce the length of line to be built 30 miles (48 kilometers) from Medellin northward, and 25 miles (40 kilometers) from Cartagena southward. Timber for ties, stone for masonry, and water will be found on the line or near by throughout its length. From the San Jorge crossing, 25 miles (40 kilometers) northwest of Cáceres, a line about 75 miles (120 kilometers) in length is believed, from trustworthy information, to be feasible over the low western ridge to Pavarandocito on the Sucio.

Maps of the line from Quito to Medellin have already been received and are on file in the central office in Washington.

Owing to the unsuitableness of the season at the time of Mr. Shunk's arrival in the lower Cauca Valley, it was not advisable to attempt a survey of the Isthmus of Panama at that date, consequently he has been transferred from Cartagena to San José de Costa Rica, with orders to begin a line at some suitable point in that neighborhood and work southward toward Panamá, reaching the isthmus in February, a favorable season for operations in that unhealthy region, and make connection with the northwestern terminus of his line in Colombia at Cañas Gordas. He sailed from Cartagena on the 16th of September and reached the capital of Costa Rica the 26th of the same month.

## SOUTH AMERICA.

## CORPS No. 3.

J. IMBRIE MILLER, *Engineer in Charge.*

W. D. KELLEY, *Assistant Engineer.*

J. R. KURTZ, *Assistant Engineer.*

WINTER L. WILSON, *Topographer.*

ALGERNON B. ALDERSON, *Draftsman.*

J. DOUGLAS FORSTER, *Junior Assistant.*

CHARLES W. RUSH, *U. S. Navy, Surgeon.*

This party was assigned the survey of the line from Quito southward through Ecuador and Peru to Cuzco, the ancient capital of the latter country.

The engineers sailed on April 10, 1891, from New York, with those of the second corps; but as Mr. Miller had been instructed to proceed in advance to Peru, to gather information regarding the route, he turned over his party to the engineer in charge of corps No. 2, and sailed direct to Callao, arriving April 27.

He reports having been courteously received and handsomely entertained by the United States minister to Peru, Mr. John Hicks; by the secretary to the United States legation, Mr. Richard R. Neill; by Admiral Brown and officers of the flagship *San Francisco*, and by private residents of the capital.

Attaché Ensign W. E. Safford, U. S. Navy, on special duty in Peru in connection with the Columbian Exposition, kindly acted as interpreter.

Interviews were secured with Gen. Remijio Morales Bermudez, the President of the Republic, and with the secretaries and other Government officials thought to be most able to forward the interests of the Commission. Letters of introduction from Mr. Leffert L. Buck, the commissioner from Peru, to El Señor Dn. Ernesto Malinowski, Mr. Edward Thornton, and other distinguished civil engineers procured much useful information. Through El Señor Malinowski permission was accorded to visit the Geographical Society of Lima and trace portions of Raimundi's new map of Peru. Copies of the text of this important work were presented.

May 6, nine days after landing, the engineer started for Guayaquil, arriving there May 10, and at Quito May 20.

El Señor J. M. P. Caamaño, governor of the Province of

Guayas, furnished transportation, as had already been done for the double engineer corps with Mr. Shunk. On arrival at camp, 3 miles north of Quito, the supplies were inspected and repacked, instruments adjusted, riding horses and pack mules purchased, and a few natives exercised in field duties, so that on June 1 the third corps camp was moved 12 miles south of Quito.

The next day both the second and third corps commenced work on the railroad survey at Quito, the third corps working southward, taking a belt contour-line topography from 3 to 5 miles in width, including all available ground for railroad location on the Quito route, and also connecting with the main valley route eastward of Quito, surveyed by Mr. Shunk.

From June 2 to October 31 (five months) the corps completed 507 miles of careful instrumental surveys, equal to a little more than 100 miles per month, of which 80 miles per month were on the main route south of Quito.

The compass and barometer were only used as checks on the instrumental alignment and levels, the measurements being taken with the stadia, the ground being too broken for accurate use of chain or odometer.

On October 31 the survey reached a point 60 miles south of Loja, in Ecuador, near the border of Peru, and 415 miles from Quito by main survey.

Some of the principal points on the location are noted below, with the distances from Quito, the altitudes above ocean level, and their respective populations.

Place.	From Quito.	Altitude.		Popula- tion.
	<i>Miles.</i>	<i>Feet.</i>		
Quito .....		9,350		80,000
Zero Monument .....	1	9,325		
Santa Rosa Summit .....	10½	9,986		
Amaguana Bridge .....	11	8,470		2,000
Uyumbicho .....	12	8,850		2,000
Tambillo .....	14	9,250		3,000
Machachi .....	22	9,760		8,000
Tiopullo Summit .....	34	11,540		
Latacunga .....	57½	9,177		15,000
San Miguel .....	65½	8,786		3,000
Ambato .....	81	8,304		18,000
Mocha .....	95½	10,810		3,000
Chimborazo Summit .....	102	12,000		
Chuquipogio .....	106	11,716		
Cajabamba .....	120½	10,715		4,000



Place.	From Quito.	Altitude.	Popula- tion.
	<i>Miles.</i>	<i>Feet.</i>	
Sicalpa.....	121	10,631	4,000
Columbe.....	134½	10,454	1,000
Guamote.....	138	10,080	8,000
Palmyra.....	148	11,650	1,000
Tigsan.....	155½	9,784	1,500
Alausi.....	161	7,857	3,000
Chunchi.....	172½	7,632	2,500
Azuay Summit.....	197	11,160	.....
Tambo.....	203½	9,990	1,000
Cañar.....	205	10,368	5,000
Curiquinga Summit.....	213¾	10,888	.....
Biblian.....	227½	8,840	3,000
Azogues.....	231	8,494	6,000
Chuquipata.....	234½	8,100	200
Cuenca.....	247	8,600	40,000

From Quito to Loja the survey follows the valley of the Andes between the Maritime and Central Cordillera. This valley is crossed by numerous mountain spurs, each of which divides the drainage (as at Tiopullo, Azuay, etc.), and the engineering problem is to cross these summits with suitable gradients and alignment, and at the same time avoid as much as possible the numerous deep ravines along the mountain slopes.

The line from Quito to Cuenca presents no extraordinary engineering features excepting high viaducts and somewhat of a lack of good building materials adjacent to the work.

South of Cuenca the ground is very broken and in places covered with dense forests, the cross ridges being frequent and irregular.

Both at Cuenca and Loja and elsewhere the Government officials and private citizens were very prominent in showing attention to the officers of the Commission, and the leading ladies made silk American flags to grace the banquet tendered the engineers.

To El Señor Antonio Borero, governor of the Province of Cuenca, and El Señor Ulpiano Valdivieso, governor of the Province of Loja, grateful mention is due. The latter was good enough to cash bank drafts on Guayaquil, so as to save delay in carriage of specie required.

The weather proved wet and cold at the high altitude selected, and there was considerable sickness caused by exposure. Mr. Miller, the chief of the party, was, soon after his arrival at Quito, attacked by a malady to which persons unaccustomed

to these high altitudes are somewhat subject, and, although warned by the surgeon of the party and by resident physicians that he ran great risk by remaining in the country, he refused to return home until after two relapses, when he was so much reduced in strength that he had to be carried to the coast in a litter. Great credit is due Mr. Miller for the very satisfactory work and good progress of his party, as well as for his pluck in remaining so long at the serious risk of his life.

Mr. William B. Sorsby, United States consul-general for Ecuador, and Mr. Martin Reinberg, the vice-consul, were very attentive to the interests of the Commission.

Upon his return to the United States Mr. Miller submitted the following:

*Estimate of cost of railway, Quito to Cuenca.*

[271.7 miles single track (main and side tracks), main track 247 miles.]

	Gold values.
Excavations and tunnels .....	\$5,203,461.35
Masonry and riprap .....	1,295,576.00
Iron viaducts and girders .....	2,392,040.00
Fencing, guards, road crossings, etc.....	248,500.00
Land damages.....	150,000.00
Engineering, legal expenses, and incidentals, .05 .....	464,478.86
<hr/>	
Total.....	9,754,056.11
Cost of roadway only.....per mile..	35,900.10
<hr/>	
Track and ballast.....	2,037,750.00
Telegraph .....	98,800.00
Passenger, freight, and water stations.....	322,900.00
Engine houses and repair shops .....	175,000.00
<hr/>	
Total .....	12,388,506.11
Total cost without rolling stock .....	45,596.83

The prices upon which the estimate is based are as follows:

Earthwork.....per cubic yard..	\$0.25
Solid rock .....	1.25
Tunnels.....per running foot..	75.00
Riprap .....	2.00
Arch culverts.....do.....	10.00
Iron work erected.....per pound..	.07½
Track and ballast complete.....per mile..	7,500.00
Loose rock .....	.75
Foundations.....do.....	.50
Box culverts .....	6.00
Abutments.....do.....	8.00

Upon the departure of Mr. Miller from Ecuador, Mr. W. D. Kelley was placed in charge of the corps and successfully conducted the survey, under trying circumstances, to Cuzco.

Messrs. Kelley, Wilson, and Forster, constituting the field force, left Loja on the 19th of October, 1891, and reached the Peruvian line on the 26th of November, covering a distance of 72 miles. At Loja it became necessary to reorganize the camp, purchase fresh mules, and hire new men. The first hired by public advertisement became frightened at the prospect ahead, and refused to enter the mountains through fear of the Indians and the wild beasts. Requisition was accordingly made upon the governor for the usual forced "peon" labor for linemen and mule drivers, the former being paid by contract to move the main camp, consisting of Messrs. Kurtz, Alderson, Rush, and Bosanquet, who had in charge the necessary provisions to carry the party through the unpopulated section between Loja and the first considerable towns in Peru. The help thus obtained moved the main camp a distance of ten leagues on the 2d, 3d, and 4th of November, but on the night of the latter date the natives escaped from camp and ran away. Requisition was again made upon the governor for more men and the necessary guard of soldiers. The men could not be obtained, but 12 soldiers under a captain were by permission of the Ecuadorian Government procured. These soldiers moved the camp, under charge of Mr. Kurtz, a further distance of  $2\frac{1}{2}$  leagues to a summit of the cordillera called Savanilla.

It was now the 20th of November, the members of the camp being disheartened, and, after holding a meeting in the rain, decided to return to Loja, thus leaving the advance party without proper provisions. Mr. Kurtz, being too ill with rheumatism to continue on, remained at Loja some time and finally returned to the United States, having been actually employed in the field less than three weeks. Mr. Bosanquet, however, makes a trip on foot through the forests and reports to Mr. Kelley the condition of affairs. Bosanquet is then placed in absolute charge of the main camp, and receives orders to return to Loja, reorganize, and conduct the main camp by another route until he overtakes the survey camp under Mr. Kelley, which was successfully accomplished, the reunion taking place at Cajabamba, Peru, February 5, 1892, Mr. Alderson and Dr. Rush accompanying Mr. Bosanquet. The action of Mr. Bosanquet in making a trip on foot through this wild region, leading a mule packed with provisions for the three surveyors in advance hidden in the depths of the forest, was

highly commendable, and probably prevented an unfortunate delay in the prosecution of the enterprise if not the loss of life.

From Loja southward the line as surveyed has a gradual ascent for 7 miles to the summit of Cajanuma, 8,302 feet, in a flat open country, thence to a summit of the cordillera, elevation 9,350 feet, 35 miles distant from Loja by a meandering line along the mountain side, the small villages of Vilcabamba and Yangana lying to the westward below. After crossing over to the headwaters of the Amazon, the line runs through a very mountainous region covered with dense forests as far as the Río Canchis, only an occasional Indian hut being encountered, the section almost destitute of food and resources, the canned supplies brought from the United States having been the main dependence. The mountain streams carry some gold, and signs of other metals are apparent, but owing to the remoteness of the locality and its inaccessibility, it would not be profitable to work mines in this section at present. At this time very long stadia sights and barometer checks had to be resorted to in order to make sufficient headway to prevent being inclosed between the swollen mountain torrents, for the rainy season was on in full force and the region was devoid of food supplies. The precipitous mountains and the dense forests, requiring much chopping, all tended to delay the work, but by clearing the hilltops, stripping the trees of bark, erecting cross-arms thereon and utilizing them as stadia rods, maximum sights of about six miles were obtained and the necessary rate of progress secured. The Indian help was short; many had the fever, much of the work being in the rain and mud. Both men and animals became greatly fatigued, and the latter having no feed except vines, all exercised an unfavorable influence upon the speed of the work.

Mention is due of the kindness of Dr. Castillo, dean of the cathedral of Loja, for the supplies he personally furnished and for his orders to the Indian communities to supply provisions to the surveying party and feed for their animals.

The next reach in the survey is that extending from the northern boundary of Peru to Cajamarca, a distance of 191 miles. From the frontier southward the same mountainous country continues for about 50 miles, when the flat bottom lands of the valley of the Marañón are encountered at an elevation above sea level of 3,000 feet. These are low, hot,

and sandy, the trees of the forest being replaced by a low, hardy growth of thorny bushes, with woods in patches. In this section numerous insects are found, while the climate is unhealthy. The line was run so as to skirt along the edges of the foothills, through the old town of Jaen, and reached the Marañón River at a point 76 miles from the Ecuadorian frontier and 12 miles south of Jaen, at an elevation of 2,550 feet, thence following the western bank of the river, in an upstream direction, a distance of 20 miles to an elevation of 2,957 feet, when such abrupt projecting spurs, 4,000 feet in height, alternating with deep-cut cross gorges at right angles to the line, were encountered that it became impracticable to adhere to the valley any longer, and the surveyors were forced to carry the line to the right and up on the table-lands. At the point where the valley was left the character of the ground was barren sand and rocks, the region was without population, without mule trails, and without provisions for man or beast.

The survey of the Marañón Valley can best be accomplished by starting at the headwaters near Cerro de Pasco and descending the stream.

By ascending to the plateaus, as indicated above, the preliminary line traversed the richest mineral and agricultural sections of the interior of Peru all the way to Cuzco and passed through the principal towns and capitals, whereas, had the conditions along the Marañón been favorable to the prosecution of the survey in an upstream direction, as was originally intended by the Commission, the line would have been run, it appears, through a region without population and without present resources. It is desirable that the alternative elevated line from Loja, Ecuador, to the neighborhood of Chota, Peru, should be surveyed in the near future. Owing to the small size of the field party, three engineers and a few Indian helpers, and the scanty supply of the plainest food, it was not practicable for Mr. Kelley to make other route inspections while pushing his line over the best route that the limited information obtainable indicated. Cajamarca, the capital of the department of the same name, was safely reached on the 15th of January, 1892, and ten days were then devoted to recuperating the worn-out mules, making records, and developing certain sections. At this town, the Prefecto, El Señor Dn. M. C. Vargas, hospitably entertained the engineers at the prefectura for ten days, cared for and fed the mules, all without charge. A ban-



quet was given the engineers and other evidences of the friendly feelings entertained by the Peruvians towards the commendable scheme of an intercontinental railway were exhibited.

The line from the Ecuadorian frontier to Cajamarca, with the exception of about 30 miles through the bottom lands of the Marañón, would be expensive and would require maximum gradients and curvatures, but when the final location is made it is believed that the elevated alternative between Loja and Cajamarca would be the one adopted. Along the southern end of this line there are several considerable towns. Near Buena Vista and Jaen coffee, tobacco, and cocoa are grown in limited quantities, and much more could readily be produced, but in the absence of means of transportation to the outside world there is no incentive for such extension. Near Cajamarca there are extensively worked silver mines, bituminous coal fields of good quality and ample quantity, together with productive agricultural lands. At this point the Marañón River lies about 40 miles to the eastward.

The next reach of the survey is that extending from Cajamarca to Huaraz, a distance of 225 miles as measured on the preliminary line. The engineers left Cajamarca January 25 and reached Huaraz March 12, 1892. From near the former town the line descends through a broad, open valley to a junction with the Río Huamachuco for a distance of about 35 miles to an elevation of 7,500 feet (the Marañón being 15 miles eastward), thence ascends the former stream to its source and to the top of the main cordillera of the Andes, at which point a spur of somewhat higher elevation and with snow-capped peaks runs eastwardly to the Marañón. Here two alternatives presented themselves, the eastern one on the Marañón slope of the main cordillera and the western one on the Pacific slope. The former would require tunneling through the numerous spurs and cross at right angles the deep gorges and waterways leading to the Marañón for a distance of nearly 150 miles, and would traverse a country very rough, but little populated and of meager natural resources. The latter crosses the main cordillera on the surface at an elevation of 13,026 feet and after a distance of 90 miles enters the beautiful valley of the Río Santa, also called the "Callejón de Huailas," thus enabling the line to be carried in its true southerly direction by easy grades up this valley, which is by far the most fertile portion of Peru, with

its large towns, thickly populated roadsides, rich mineral lands both east and west, gold and silver predominating. These mines are worked on a large scale, as easy communication with the coast permitted the introduction of heavy machinery and supplanted the handling of the ores by the primitive methods of manual labor formerly in vogue.

Lower down in the same valley is the sugar cane, while to the eastward, in an almost continuous line, rise the snow-capped summits of the Andes, thus affording within a few hours' journey all degrees of climate, temperature, and vegetation. For the above reasons, the latter route was the one selected by Mr. Kelley, and in his opinion has proven the better. The gold districts of Pallasca and Cabana, the richest in Peru, are on the immediate line of the survey, and when the construction of the road is once commenced, the nearness to the coast and the facilities for getting machinery and supplies would lessen the cost of building. Moreover, the Chimbote railroad, which was destroyed by washouts, is likely to be rebuilt in the near future, and this, with the local traffic here existing, in itself remunerative, all confirm the advantages of the Pacific to the Marañón slope of the Andes.

The surveyors arrived at Cajabamba, 60 miles south of Cajamarca, on the 3d of February and were met there on the 5th by the supply camp from Loja under Messrs. Bosanquet, Alderson, and Rush. This latter party, being under mule hire to Caraz, 125 miles farther, continued the direct line of march to the latter place, which was reached February 21, intending to await the arrival of the surveying party at that point and utilize the time in drafting the maps then in arrears. On the arrival of Mr. Kelly's section at Caraz, March 4, he found the other party all sick, Mr. Alderson being in bed with a high fever and not in condition to be moved, while Dr. Rush and Mr. Bosanquet were also ill. Under these circumstances it was impossible for Mr. Bosanquet's party to continue the march to Cerro de Pasco, and accordingly as soon as Mr. Alderson could be moved he was carried to the coast, and he with Dr. Rush returned, via Lima, to the United States, where they arrived in April, 1892. Under orders from the Commission, Mr. Bosanquet's party was disbanded at Lima, and he in person proceeded to join Mr. Kelley in the field at Huancayo, where he arrived May 10, 1892.

The unfortunate illness of Messrs. Kurtz, Alderson, and Rush

and the Savanilla mishap, all show the difficulties under which the survey was prosecuted to a successful end by the unswerving determination and skillful management of Mr. Kelley, ably seconded by Messrs. Wilson and Forster, who remained with him to the end.

The next stretch of survey to be considered is that from Huaraz to Cerro de Pasco, a distance of 144 miles as measured along the preliminary line actually run. Leaving Huaraz March 16, Cerro de Pasco was reached April 6, 1892. From the former town southward the line ascends by easy gradients and cheap construction a distance of 16 miles along the Rio Santa to the town of Recauy, situated at the head of the industries of the valley and the populous district and where are located extensive silver smelting works.

At Recauy two alternatives present themselves; but, owing to the reduced size of the surveying corps, only one could be examined: First, an eastward line requiring a triple crossing of the cordillera via Huallanca and the Marañón slope of main chain to Cerro de Pasco. Secondly, a westward line on the Pacific slope, passing by Cajatambo and crossing a high spur of the cordillera, forming one of the above-mentioned triple crossings. The former route passes through the large coal and silver-mining districts of Huallanca and enters the populous department of Huanuco, which is very fertile and productive. The latter crosses a spur with as high a summit as that of the main ridge, but without the coal and silver industries and population to recommend it, and besides would require a steeper and more troublesome ascent in order to attain the high pampa of Cerro de Pasco. Under these circumstances the first alternative was selected and is believed by Mr. Kelley to be the better route, although before final location the other should be surveyed. Near Recauy the main cordillera is crossed at an elevation of 14,927 feet and the two spurs can be crossed on the surface by developing the line along the rocky and snowy mountain sides, at elevations of 15,199 and 15,128 feet, but it is believed that tunnels here would be preferable.

Thence descent is made by a rather narrow valley to Huallanca, where coal is abundant in quantity and is of good quality, while the silver ores pay as high as \$320 per ton, those as low as \$37 per ton being cast on the dump. Smelting works with improved machinery are being established. At this point hospitalities were extended to the engineers, while the pre-

fect and certain citizens of Huanuco, 32 leagues distant, came to pay their respects to the representatives of the Commission. From Huallanca to Cerro de Pasco, 84 miles, owing to the crossing at right angles of the numerous gorges of the headwaters of the Marañón, the line would be costly, except the last 15 miles at the Cerro de Pasco end. This latter town is famous for its silver mines, its business industries, and extensive commerce, and for the number of foreigners to be found there. Within a radius of 12 miles the country is dotted with small mining towns and haciendas for working silver. There is a railroad 3 leagues long from the mines in Cerro de Pasco to the reduction works. The mines are mostly under the city, and in addition to the railroad thousands of llamas are used to transport the ore.

The city has an elevation of 14,293 feet and consequently no timber exists in its immediate vicinity, but barley straw grows in scattered patches, but never produces grain. The llamas graze off the very short pampa pasturage while mule feed has to be brought from a distance. Coal, brought some 10 leagues, is used by the smelting works, the railroad, and the richer families, but the fuel most in use is the llama dung, gathered in bags by the Indian women. A sun-dried sod, called "champa," is also used for the same purpose. A banquet under the auspices of El Señor Chavez, acting Prefecto of the Department of Junin, was tendered the engineers at this point, while El Señor Vildasola, United States vice-consul, showed many attentions. Here telegraphic instructions were received from the central office in Washington to continue the survey to Cuzco.

After reorganizing his party, Mr. Kelley left Cerro de Pasco on the 18th of April and reached Huancayo, 140 miles distant, May 10. From Cerro de Pasco southward the route lies across the high pampa at elevations varying from 13,400 to 14,000 feet above sea level, and passes by the eastern side of Lake Junin. So far as the topography of the country is concerned, this is the cheapest portion of the line to be constructed, the grades being easy, no heavy crossings required, and a good alignment attainable. However, wooden cross-ties in Cerro de Pasco cost \$1.25 each, in native money, and prices of all classes of commodities are very high. After leaving Junin the line passes over a slight summit (13,751 feet) and then descends by a tributary into the Río Oroya Valley to the town of the same name. The route followed is practically that of the Oroya and Cerro



de Pasco Railroad, and on April 28 Mr. Kelley's party were in camp with the engineers of that road and exchanged elevations with them. Oroya is 137 miles from Lima, and the railroad is already built from the latter place to Casapalca, which is  $41\frac{1}{2}$  miles from Oroya, this latter distance being covered by mule traffic in one and a half days. This interval is now under construction, and it is expected that the road will be open to the public by the 1st of January, 1893. From Oroya to Huancayo, 68 miles, the line surveyed follows down the Oroya River, encountering no difficulties, and for the last 28, or from Jauja to Huancayo, passes through an open country, rich agriculturally, but without mineral wealth, at elevations varying from 9,000 to 10,000 feet. This section is claimed to be adapted to tea culture, although none is grown there now. It contains many large towns, and the construction of a railroad would develop a considerable passenger and local freight traffic.

After enjoying a banquet, the surveyors left Huancayo May 13 and reached Ayacucho, 117 miles distant, June 1. From Huancayo southward the survey continues down the Oroya River a distance of 47 miles to Izcuchaca, at an elevation of 9,413 feet. At this point two routes became available; the first continues down the Oroya River to its junction with the Río Huanta, and then ascends that stream to Ayacucho. The second adheres to the highlands in a generally straight direction. The first having been surveyed by other parties, although it may be the better of the two, Mr. Kelley decided to follow the second, so as not to duplicate the surveys, but obtain additional data. The line as actually run passes some towns and is not far from the rich quicksilver mines of Huancavelica, which lie to the westward of the best direction. The section under consideration is but slightly productive, is without timber, without mines, and but sparsely populated by poor Indians. The first route indicated above would pass through a timbered country and through lower levels into or near the sugar, coffee, and tobacco district below Huanta. Special mention should be made of the kindness of the prefecto, El Señor Leonardo Caveró, and other officials at Ayacucho, and of the banquet tendered the members of Mr. Kelley's party.

From Ayacucho to Abancay is 137 miles. The former town was left June 6 and the latter reached July 8, 1892. The survey gradually ascends from an elevation of 8,900 feet at Ayacucho to that of 14,062, where it crosses a ridge 38 miles



from the starting point, and thence descends to an elevation of 7,040 at the Río Pampas by a side hill grade line 44 miles long. The Río Pampas was crossed on rafts June 18, and the work continued, the line ascending the valley of the Río Huancaray by an easy grade to a summit of the main cordillera having an elevation of 14,628 feet. This ridge here runs east and west, the town of Andahuailas being situated on the other side of the ridge at a distance of five leagues to the eastward. From the summit just mentioned the line then descends by the use of much curvature to an elevation of 5,800 feet in the valley of the Río Pachachaca, lying at right angles to the line of survey. After crossing this stream there is another ascent up the valley of the Abancay to the village of that name, the route passing through the large sugar estates of Dr. Letona. In the section between Ayacucho and Abancay small villages and a sparse Indian population are found. The country, being generally high, is adapted to sheep raising, and although minerals are said to exist, no mines had been opened along the route. Owing to the crossing of the rivers Pampas and Pachachaca, the transversal ridges, and the main cordillera, the construction of this portion of the Intercontinental Railway would be expensive.

As portion of the route was believed to be infested by hostile Indians, a cavalry escort for a distance of 40 miles and arms and ammunition were furnished the engineers by the Government authorities at Ayacucho.

As elsewhere, courteous attentions were shown the Commission's representatives. Dr. Letona entertained them for several days, and provided feed for the animals free of charge. The prefecto of Abancay, El Señor Juan Pablo Palosminos, was equally attentive, and a banquet was one of the hospitalities extended here.

The next reach of the survey, 69 miles, is that from Abancay to Cuzco, where the instrumental work ceased. The former town was left July 11, and the ancient capital of the Incas reached July 20, 1892.

Leaving Abancay, the line ascends to a summit elevation of 12,900 feet, and thence descends to that of 6,083 in the valley of the Apurimac, through a populous district, fine agriculturally, and producing considerable quantities of sugar cane. Crossing the river, there is another ascent to a summit of 12,438 feet, thence by a light gradient a descent by hillside work into the valley at Cuzco, 11,103 feet above sea level.

Before final location a survey of the valleys of the rivers Pampas and Apurimac in a down stream direction towards the eastward and northward would seem to be advisable as well as the examination of an alternative line from the 12,900 foot summit south of Abancay to some point on the existing railroad between Marangani and Santa Rosa, thus adhering to the table lands and avoiding the deep crossing of the Apurimac.

A three days' mule ride of 75 miles brought the engineers to Secuani, the present terminus of the Arequipa, Puno and Cuzco Railroad. Secuani is 111 miles from Puno, on Lake Titicaca, situated upon the western boundary of Bolivia. Cuzco is 453 miles from Mollendo on the seacoast, of which distance 378 miles are in operation. It is therefore apparent that by carrying the instrumental survey to Cuzco it has practically been carried to the frontier of Bolivia.

Owing to the kindness of Mr. McCord, the entire party and baggage were passed to the seacoast, and an excursion to Puno afforded an opportunity to inspect the whole line. Arequipa was reached July 28, and the usual courtesies and banquet extended by the prefecto, El Señor Abrill. At this point, Mr. Kelley was met by Dr. Parro, director-general of public works of Peru.

Arriving at Lima August 2, the engineers were taken ashore in a special launch and met by officials of the Government. A private reception was held by Dr. Parro at his residence, a banquet by the president of the cabinet, El Señor Carlos M. Elias, in the exposition building, and an official presentation to the President of the Republic and his cabinet took place, all in honor of the Commission's representatives. Courtesies were also shown by Mr. R. R. Neill and others of the United States legation; by Mr. Holcombe, of the banking firm of Grace Bros. & Co., and by Chief Engineer Thorndike, of the Oroya Railroad, who provided an excursion over his line in a special observation car. Leaving Lima August 9, the party arrived in Washington on the 30th of the same month, since which time they have been engaged in working up the data collected and in preparation of the finished maps.

*Some of the principal points on the line surveyed, their altitudes above sea level, and approximate population.*

Locality.	Dis- tances.*	Eleva- tion.	Popula- tion.
<i>South of Quito.</i>			
	<i>Miles.</i>	<i>Feet.</i>	
Quito (plaza) .....		9,350	80,000
Cuenca† .....	228.3	8,600	40,000
Zaraguro .....	309.8	8,456	5,000
Loja .....	341.0	7,138	18,000
Vilcabamba .....	361.5	5,476	600
Yangana .....	369.8	6,273	200
Río Canchis‡ .....	413.1	3,000	.....
<i>South of Río Canchis.</i>			
Jaen .....	64.3	3,389	300
Río Maraón (at first point touched) .....	76.3	2,550	.....
Río Maraón (at point of leaving) .....	96.9	2,957	.....
Chota .....	143.0	10,000	7,000
Cajamarca .....	191.2	9,843	30,000
Cajabamba .....	250.6	9,374	15,000
Huamachuco .....	266.1	11,035	15,000
Summit of cordillera .....	283.8	13,026	.....
Río Mollepatá .....	303.1	7,336	.....
Pallasca .....	306.9	10,350	6,000
Summit of spur of cordillera .....	327.7	14,179	.....
Corongo .....	338.3	9,908	7,000
Río Santa .....	352.1	3,952	.....
Caraz .....	376.8	7,174	15,000
Huaraz .....	416.0	9,537	25,000
Recuay .....	431.7	10,615	6,000
Huapasca (summit of spur) .....	456.8	15,199	.....
Yanachachas (summit of spur) .....	463.6	15,128	.....
Summit of cordillera .....	464.7	14,927	.....
Huallanca .....	476.5	11,302	4,000
Cerro de Pasco .....	560.4	14,293	8,000
<i>South of Cerro de Pasco.</i>			
Lago de Junin .....	33.7	13,422	.....
Oroya .....	72.2	12,166	300
Jauja .....	112.6	11,145	12,000
Other towns .....			50,000
Huancayo .....	140.3	10,635	20,000
Río Huancayo (at Izeuchaca River) .....	187.3	9,413	.....
Summit of spur .....	197.8	14,723	.....
Ayacucho .....	256.9	8,900	40,000
Summit of spur .....	294.6	14,062	.....
Río Pampas (at crossing) .....	321.9	7,040	.....

\* Distances measured on the preliminary line.

† Cuenca is 247 miles south of Quito on the "location."

‡ Dividing line between Ecuador and Peru.

*Some of the principal points on the line surveyed, their altitudes above sea level, and approximate population.—Continued.*

Locality.	Dis- tances.	Eleva- tion.	Popula- tion.
<i>South of Cerro de Pasco—Continued.</i>			
Huancaray .....	<i>Miles.</i> 341.5	<i>Feet.</i> 9,669	3,000
Summit of cordillera .....	364.8	14,628	.....
Río Pachachaca .....	388.8	5,800	.....
Abancay .....	393.8	7,853	7,000
Summit of spur .....	401.0	12,900	.....
Río Apurímac at (crossing) .....	415.7	6,083	.....
Summit of spur .....	433.4	12,438	.....
Cuzco (end of survey) .....	462.7	11,003	60,000

*Summary of work of Corps No. 3.*

	Main line.	Spur lines.	"A" points.	Totals.
	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>
Quito to Ecuadorian frontier .....	413.1	84.7	57.5	555.3
Quito to Cerro de Pasco .....	973.5	127.5	73.9	1,174.9
Quito to Cuzco .....	1,436.2	172.3	90.8	1,699.3
Total number of miles run .....	.....	.....	.....	1,699.3

*Population near line of survey.*

Ecuador .....	215,500
Peru .....	384,600
Total .....	600,100

Throughout the entire distance a stadia transit and level line was run, the barometer being used simply to check up. The time employed in the field work was that from June 2, 1891, to July 20, 1892, or one year one and one-third months. The maximum elevation attained was 15,200 feet above sea-level and the minimum 2,500 feet. The maps covering the Ecuadorian section were made in the field by the survey camp, while those relating to the Peruvian portion of the line are now being constructed in Washington. The total survey of 1,700 miles will be exhibited on about 50 maps and as many profiles. The estimate of the cost of construction of the section between Quito and Cuenca, by Mr. Miller, has already been given. Mr. Kelley submits the following approximate estimate of the whole line:

Quito to Cuenca (by Mr. Miller):	
247 miles, at \$35,900 per mile .....	\$8,867,300
Cuenca to Loja, 113 miles:	
36 miles, at \$25,000 per mile .....	900,000
77 miles, at \$55,000 per mile .....	4,235,000
Loja to Peruvian boundary, 72 miles:	
5 miles, at \$20,000 per mile .....	100,000
67 miles, at \$60,000 per mile .....	4,020,000
Ecuador .....	18,122,300
Peruvian boundary to Cajamarca, 191 miles:	
55 miles, at \$20,000 per mile .....	\$1,100,000
136 miles, at \$52,000 per mile .....	7,072,000
Cajamarca to Huaraz, 225 miles:	
40 miles, at \$18,000 per mile .....	720,000
185 miles, at \$50,000 per mile .....	9,250,000
Huaraz to Cerro de Pasco, 144 miles:	
60 miles, at \$20,000 per mile .....	1,200,000
84 miles, at \$55,000 per mile .....	4,620,000
Cerro de Pasco to Huancayo:	
140 miles, at \$20,000 per mile .....	2,800,000
Huancayo to Ayacucho, 117 miles:	
47 miles, at \$25,000 per mile .....	1,175,000
70 miles, at \$55,000 per mile .....	3,850,000
Ayacucho to Abancay, 137 miles:	
43 miles, at \$30,000 per mile .....	1,290,000
94 miles, at \$55,000 per mile .....	5,170,000
Abancay to Cuzco, 69 miles:	
29 miles, at \$25,000 per mile .....	725,000
40 miles, at \$40,000 per mile .....	1,600,000
Peru .....	40,572,000
Ecuador .....	\$18,122,300
Peru .....	40,572,000
Total .....	* 58,694,300

\*Calculated on the mileage of the preliminary survey.

The line by location, owing to curvature in development, etc., may be longer, but the cost of construction of the Intercontinental trunk line would depend very much upon the cost of getting machinery, supplies, tools, materials, etc., into the interior. The building of the several roads now projected from the coast into the interior, as well as the utilization of those already existing, would materially lessen the outlay.

A. J. CASSATT,

*Chairman Executive Committee.*

WASHINGTON, D. C., January 31, 1893.



# INTERCONTINENTAL RAILWAY COMMISSION.

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(Arranged alphabetically according to nations.)

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John Stewart.

### SALVADOR.

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The President of the Commission is *ex officio* a member of each committee.





Intercontinental  
Surveys made  
" projected  
Other Railroad  
In Operation  
Projected

W.D.K. Wash. D.C. Dec. 1892.

























